Behavior Analytic Studies of Creativity: A Critical Review

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Studies that treat creativity as operant behavior were critically reviewed. Of the twenty studies, most met minimal requirements for methodological adequacy; all provided at least some evidence for increased creative responding. Major difficulties involved potential confounds between instructions and contingencies, lack of an independent record of the training interaction, lack of social validation data, and very limited evidence for generalization. Several issues were discussed: problems in the behavioral definition of creativity, objections to the use of contingent reinforcement, and the need for empirical analysis of the creative process.

As noted by Bijou (1979) and Sloane, Endo, and Della-Piana (1980), the experimental analysis of behavior is often criticized for failure to deal with complex human phenomena such as creativity. Such a criticism is no longer tenable: Studies conducted over the past 13 years clearly address the experimental analysis of creativity. What remains unclear is the methodological and conceptual adequacy of these studies and whether the research has dealt with the special problems of creativity. Recent reviews by Goetz (1982) and Sloane et al. (1980) have summarized some of the behavioral work but have not provided a comprehensive and critical review.

In this paper, we review published studies on the training of creativity as operant behavior. The behavior analytic conception of creativity will first be described, followed by a review of the methodological characteristics and findings of the empirical studies. Finally, we will discuss some of the difficulties raised by the analysis of such a complex, subjective, and highly valued activity as creativity. Specifically, the discussion will focus on problems in (a) the definition of a creative response, (b) the use of contingent reinforcement, and (c) the analysis of the creative process.

The studies included in this review were specifically concerned with "creativity" as indicated by their title and text. In addition, these studies met either or both of the following criteria: Creativity was clearly conceptualized as operant behavior in the introduction and discussion, or the study employed a behavior-analytic, individual subject methodology (i.e., emphasis on discrete, observable responses of individual subjects) to examine behaviors labelled by the authors as creative. This disjunctive criterion was used because some studies were based on an operant conception of creativity, but used a group design with between subjects replication, whereas other studies used behavior analysis methodology without clearly indicating that creativity constitutes operant behavior. Operant studies in which "creativity" did not appear in the title or text of the report were not included in this review, even when such studies involved the development of new responses.

BEHAVIOR ANALYTIC CONCEPTION OF CREATIVITY

The traditional literature on creativity is vast (see Rothenberg & Greenberg, 1976 for a bibliography of over 6,800 references). Creativity has been characterized in terms of the sublimation of unconscious drives (Freud, 1928), a set of intellectual traits (Guilford, 1959), a constellation of personality characteristics (Barron, 1969), the realization of individual potential (Rogers, 1959), and in numerous other ways. Although much of

the traditional literature appears to emphasize a static, measurement approach, the training of creativity has been a major concern of Torrance (e.g., 1962, 1965) and others. The focus of such training is generally on the development of a general skill, as measured by standardized tests.

In contrast to traditional approaches, a behavior analysis of creativity treats creative activity as behavior that follows the principles of operant behavior. The analysis proceeds on the general assumption that the three-term contingency of discriminative stimulus, operant response, and consequent event can be used to describe the occurrence of something creative. The goal of a behavioral analysis is to identify the functional properties of various events in creative activity (see Skinner, 1970), and to demonstrate functional control through systematic experimentation. In applied behavior analysis, the goals will additionally include the development of practical techniques that result in socially important changes in creative activity.

In all definitions of creativity, some conception of "originality" or "novelty" is an essential, though not always sufficient component. Thus, a behavior analysis of creativity must account for the appearance of behaviors that are novel, and the analysis must specify precisely the kind of "originality" that makes something creative. Skinner (1974) dealt with the appearance of novel behaviors as follows:

Operant conditioning solves the problem more or less as natural selection solved a similar problem in evolutionary theory. As accidental traits, arising from mutations, are selected by their contributions to survival, so accidental variations in behavior are selected by their reinforcing consequences ... creative thinking is largely concerned with the problems of "mutations." Explicit ways of making it more likely that original behavior will occur by introducing "mutations" are familiar to writers, artists, composers, mathematicians, scientists, and inventors. Either the setting or the topography of behavior may be deliberately varied. The painter varies his colors, brushes, and surfaces to produce new textures and forms. The composer generates new rhythms, scales, melodies, and harmonic sequences, sometimes through the systematic permutation of older forms, possibly with the help of mathematical or mechanical devices. The mathematician explores the results of changing a set of axioms. (pp. 114–115)

Skinner's conceptualization explains the occurrence of something novel, but we are left with the problem of how to define originality or novelty. This problem was briefly discussed in *Science and Human Behavior* (Skinner, 1953) where Skinner clearly suggested that originality depends on the controlling variables:

We do not call original that response which is obviously imitative or controlled by explicit verbal stimuli, as in following spoken or written instructions. We are not wholly inclined to call a response original, even though it has never been made before, when it is the result of some established procedure of manipulating variables—as in routine mathematical operations or the use of syllogistic formulae .... We reserve the term original for those ideas which result from manipulations of variables which have not followed a rigid formula and in which the ideas have some other sources of strength. (p. 254)

In *Verbal Behavior,* Skinner (1957) elaborated at length on the notion of multiple sources of stimulus control, and discussed the role of multiple causation in new combinations of fragmentary responses, literary style, and humor. Although he did not explicitly define such behaviors as creative, the implication from the passage above and from *Verbal Behavior* is clear: Originality is defined according to the process by which the painting, poem, invention, or theory came about, and not on the basis of the product alone.

Sloane et al. (1980) developed an analysis of creativity based on Skinner's (1957) discussion of stimulus control in *Verbal Behavior*. Specifically, Sloane et al. distinguished between "formal" and "informal" sources of stimulus control. Formal control occurs when a point-to-point correspondence exists between the discriminative stimulus and the response (see Skinner, 1957, p. 243). "Informal control" occurs when a response is under multiple sources of control, especially by thematic variables or by sources that are unusual in a given verbal community. For example, if a child paints a cityscape in bright colors immediately after viewing a similar picture using similar colors, the painting is under formal control of the other picture and is not described as creative, but if the child decided to use the bright colors partly because the city is "noisy" and "exciting," then we might

suspect informal control and view the act as creative. According to this view, "informal stimulus control" makes a response creative, rather than any particular topography.

As noted by Sloane et al. (1980), behavior analysis research on creativity has generally used response topography, rather than informal stimulus control, to define creativity. Typically, behavioral studies have used two definitions of increased creative responding: (1) changes in the diversity of responses, such as the number of different geometric forms in a drawing and (2) occurrence of responses not previously used by the subject (i.e., originality or novelty). Some studies additionally use independent judges to define or confirm an increase in creativity (e.g., Baker & Winston, in press). Such definitions focus on the product of the behavior. The difference between Skinner's definition of "originality" and the way in which "originality" has been operationalized in the literature is a major issue. We will return to this problem following a review of the empirical research.

METHODOLOGICAL REVIEW

Twenty published studies in which creativity has been treated as an operant behavior are summarized in Tables 1 and 2. Table 1 describes the basic procedures and results of each study, while Table 2 summarizes the methodological characteristics and difficulties of each study.

General Procedures and Findings

Subjects and settings. Except for Pryor, Haag, and O'Reilly's (1969) use of porpoises, all subjects in these studies have been children and college students. All but one of the studies involving human subjects (i.e., Baker & Winston, in press) took place in a classroom or preschool setting.

Response modalities. A variety of response modalities have been studied. Pryor et al. (1969) examined gross motor movements in porpoises. Drawing and painting (e.g., Holman, Goetz, & Baer, 1977), story-telling (i.e., Baker & Winston, in press) and blockbuilding (Goetz

& Baer, 1973) have been studied in children aged 3 to 6 years. Creative writing has been studied in children aged 8 years and older (i.e., Ballard & Glynn, 1975). A few experiments have studied responses to variations of standardized creativity tests (Funderbunk, 1976; Glover & Gary, 1976), such as the Torrance Tests of Creativity (Torrance, 1966).

Parsonson and Baer (1978) studied a different aspect of creativity. Although the other studies included in this review examined a created product such as a drawing or block structure, Parsonson and Baer studied improvisation, a form of problem-solving. Preschool children were trained to find a substitute to replace the specifically designated, but unavailable tool ordinarily used to solve the problem. For example, using a pipe cleaner to thread through the eyelets of a shoe when a shoe lace was unavailable was scored as an improvised or creative response.

Training techniques. Positive reinforcement in the form of praise, points, or tokens contingent upon a specific response or type of response has been the most frequent training procedure. The majority of the researchers employed reinforcement delivered by the experimenter. In contrast, Ballard and Glynn (1975) trained 8 and 9 year old children to self-determine and self-administer points contingent on objective parts of speech in their written stories. A different self-control procedure was employed by Baker and Winston (in press). Five and six year old children were taught to self-instruct and to praise themselves for acting on the instructions.

Some studies have combined social reinforcement (praise) with points or tokens exchangeable for edibles, toys, or free time (i.e., Brigham, Graubard, & Stans, 1972; Campbell & Willis, 1978). Other studies have provided children with a toy at the end of each session (i.e., Fallon & Goetz, 1975; Goetz, 1981). The effect of such reinforcement on the subjects' behavior outside the experimental sessions has not been examined. The possibility that "overjustification effects" (Lepper & Greene, 1978) may arise from such reinforcement procedures is an im-

TABLE 1

Basic procedures and results

Authors/ subjects	N	Response modality	Intervention procedure	Creativity measures	Results
Baker & Winston (in press) 5–6 year-olds	6	Felt pen drawing, Story-tell-ing	Self-instructional package: Model-ing + instruc-tion + self-in-struction + self praise	1—Diversity of ob-jects, people, ac-tions (study 1) 2—Subjective rat-ings of novelty (study 2) 3—Subjective rank-ings of creativi-ty	1. Increased di-versity and novelty ratings 2. No cross-task generalization 3. Higher creativ-ity rankings for drawings high in diversity and novelty, but not for sto-ries
Ballard & Glynn (1975) 8–9 year-olds	14	Story-writing	1. Self-assessment + self-record-ing of writing responses 2. Self-determined and self-admin-istered rein-forcement (points)	1. Objective writ-ing responses: sentences, action words, describ-ing words 2. Subjective rat-ings of quality	1. Increased di-versity of ob-jective writing responses 2. Increased qual-ity ratings 3. Concurrent in-crease in on-task behavior
Brigham, Grau-bard, & Stans (1972) 5th-grade boys	13	Story-writing	Reinforcement: 1. Points 2. Praise	1. Objective writ-ing responses: words, different words, new words 2. Subjective rat-ings of quality	1. Increase in number of words 2. Results for dif-ferent words and new words equivocal 3. Increased qual-ity ratings
Campbell & Wil-lis (1978) 10–12 year-olds	32	Story-writing	Reinforcement: 1. Tokens 2. Praise	1. Objective writ-ing responses: fluency, flexibili-ty, elaboration 2. Torrance Tests of Creative Thinking (TTCT)	1. Increase in ob-jective writing responses 2. Higher post-test scores on TTCT
Fallon & Goetz (1975) 3–4 year-olds	3	Felt pen drawing	Reinforcement: 1. Descriptive praise 2. Toy at end of session	1. Form diversity 2. Number of new forms	Increased form di-versity and new forms
Funderbunk (1976) 5th–6th graders	45	Written re-sponses: 1. Unusual uses test (UUT) 2. Squares test (ST) 3. Circle test (CT)	Reinforcement: points	Novel responses on UUT and ST	Increased novelty
Glover (1980) college students	14	Written re-sponses 1. UUT 2. Problem solutions exercise (PSE)	1. Instructions 2. Practice 3. Reinforcement: points toward course grade	1. Objective writ-ing responses: fluency, flexibili-ty, elaboration, originality 2. TTCT	1. Increase in ob-jective writing responses 2. Higher post-test scores on TTCT

TABLE 1
Continued

Authors/ subjects	N	Response modality	Intervention procedure	Creativity measures	Results
Glover & Gary (1976) 9–10 year-olds	8	Written responses on UUT	1. Instructions 2. Practice 3. Reinforcement: team points	1. Objective writing responses: fluency, flexibility, elaboration, originality 2. TTCT	1. Increase in fluency, flexibility, and elaboration 2. Slight increase in originality 3. Higher post-test scores on TTCT
Glover & Sautter (1977) 15–18 year-olds	31	Writing: illustrations of concepts	1. Instruction 2. Practice 3. Reinforcement: points toward course grade	1. Objective writing responses: fluency, flexibility, elaboration, originality 2. TTCT	1. Increase in objective writing responses 2. Higher post-test scores on TTCT
Goetz (1981) 3 year-olds	9	Blockbuilding	Reinforcement: 1. Descriptive praise 2. Toy at end of session	1. Form diversity 2. New forms	1. Increase in new forms for 4 children 2. Increased form diversity for all children
Goetz & Baer (1973) 3–4 year-olds	3	Blockbuilding	Reinforcement: descriptive praise	Form diversity	Increased form diversity
Goetz & Salmonson pre-schoolers	3	Easel painting	Reinforcement: 1. Descriptive praise 2. General praise	Form diversity	1. Increased form diversity with descriptive praise 2. Increased form diversity for 1 of 2 children with general praise 3. When both descriptive and general praise used, descriptive resulted in greater increments
Holman, Goetz, & Baer (1977) 3–5 year-olds	5	Study 1 1. Easel painting 2. Block building Study 2 1. Block building 2. Lego building 3. Felt pen drawing 4. Easel painting	Reinforcement: 1. Descriptive praise 2. Tokens-exchangeable for desired toy	1. Form diversity 2. New forms	1. Increased form diversity and new forms 2. Little cross-task generalization
Lane, Lane, Friedman, Goetz, & Pinkston (1982) 3–4 year-olds	18	1. Felt pen drawing 2. Collage construction	1. Descriptive reinforcement 2. Tokens	1. Form diversity 2. New forms	1. Increased form diversity 2. No increase in new forms 3. No generalization

TABLE 1

Continued

Authors/ subjects	N	Response modality	Intervention procedure	Creativity measures	Results
Maloney & Hopkins (1973) 4–6th graders	14	Story-writing	1. Instructions 2. Feedback 3. Reinforcement: team points	1. Objective writing responses: adjectives, action verbs, sentence beginnings 2. Subjective creativity rankings	1. Increased diversity of obj. writing responses 2. Higher creativity rankings for stories written after intervention
Maloney, Jacobson, & Hopkins (1973) 3rd graders	19	Story-writing	1. Lectures 2. Requests 3. Reinforcement: a) general praise b) specific praise c) free time	1. Objective writing responses: words, nouns, adjectives, adverbs, prepositions, action verbs, sentence beginnings 2. Subjective creativity rankings	1. Objective writing responses increased with combination of intervention procedures 2. Lectures and requests alone not effective 3. Stories written when action verbs reinforced were rated most creative
Maltzman, Bogartz, & Breger (1958) college students	120	Word association	1. Reinforcement: praise 2. Instructions	1. Statistical infrequency 2. UUT (for generalization)	1. Less frequent association 2. Generalization results unclear
Parsonson & Baer (1978) 3–6 year-olds	5	Tool improvisation	1. Reinforcement: —descriptive feedback —praise 2. Training with multiple exemplars	New improvisions of effective tools	Improvisations increased for trained tools. No generalization to untrained tools.
Pryor, Haag, & O'Reilly (1969) porpoises	2	Gross body movements	Reinforcement: food	New movements	New movements in 6 of 7 sessions
Ryan & Winston (1978) 3–5 year-olds	3	Drawing	Reinforcement: cartoon movies	1. Color diversity 2. Form diversity 3. Subjective creativity rankings	1. Increased color diversity 2. Increased form diversity for 2 of 3 children 3. Drawings with increased form diversity, but not increased color diversity, ranked as more creative

portant issue, and is discussed in a later section of the paper.

In many of the studies, a number of different training procedures (instruc-tions, modeling, practice, etc.) are used in combination. One difficulty with this approach is that the efficacy of the indi-vidual components can not be deter-

mined. Whether the observed results are due to the entire package or to one or more of its components is unknown. In some studies, verbal feedback and other reinforcers were always administered simultaneously, and the separate contribution of different reinforcers is unknown (e.g., Brigham et al., 1972).

Another problem concerns the use of instructions in combination with reinforcement. Because the instructions may convey to subjects how they are to perform, the effects of the instructions and the contingencies are confounded (Redd, 1974). Thus, the changes in behavior may be due to either the contingencies or the instructions. This potential confound was present in all studies utilizing instructions.

Creativity measures. As can be seen in Table 1, the primary measures of creativity were diversity or fluency, usually defined in terms of number of different responses, and some measure of novelty. With the exception of one study (Baker & Winston, in press), novelty has been defined relative to the subject's previous behavior or products thereof. For example, Goetz and her colleagues examined new painting or blockbuilding forms per session (form diversity) and new forms across all sessions (Goetz, 1981; Goetz & Baer, 1973; Holman, Goetz, & Baer, 1977). Baker and Winston (in press) examined a more subjective and broadly defined concept of novelty in children's work. Novelty was defined relative to the content of work typically produced by 5 and 6 year old children, as rated by two judges with extensive experience in children's art.

Some studies (Campbell & Willis, 1978; Glover & Sautter, 1977) have utilized behaviorally defined creativity measures related to the four creativity factors described by Guilford (1959)— fluency, flexibility, originality, and elaboration. A few studies (e.g., Glover & Gary, 1976) have supplemented behaviorally defined creativity measures with pre-test and post-test scores on the Torrance Tests of Creative Thinking (Torrance, 1966).

Results. The results of the reviewed studies are summarized in Table 1. For all studies, an increase in at least some of the creativity measures was observed. Substantial differences in effectiveness were observed across measures or across different aspects of the training procedures. For example, Goetz (1981) found that 7 of 9 subjects showed an increase in new blockbuilding forms, while only 4 of 9 subjects showed increased diversity of block building forms within each session. In the Maloney, Jacobson, and Hopkins (1973) study, creativity measures increased when a combination of lectures, requests, praise, and contingent free time were used. Lectures and requests alone had no effect. The results of the studies, taken together, do not provide any clear indication that certain techniques and contingencies are more effective than others.

Specific Design Characteristics and Difficulties

Designs. Various experimental designs have been used throughout this literature (see Table 2). The majority of studies employed single subject analyses, usually in the form of a multiple baseline across subjects or multiple baseline across behaviors. The studies involving creative writing, however, used group designs, with the effects assessed by between subject replication. In general, replication procedures have been adequate.

Observational procedures. Eight of the twenty studies included in this review had various aspects of the experimental sessions observed and recorded by an independent observer. For example, Holman et al. (1977) had an independent observer record each instance of reinforcement by the experimenter as well as other relevant events during the session, such as the names, number, and sequence of all forms produced by the child and the duration of the session. Although the recordings of an independent observer may eliminate the potentially confounding effects of unplanned contingencies generated by the experimenter's behavior, the studies that have taken this precaution have generally used the same ob-

TABLE 2

Specific design characteristics and deficiencies

Authors	Design	Method[a]					Comments
		1	2	3	4	5	
Baker & Winston (in press)	Multiple baseline across	Y	Y	N	Y	A, B	
Ballard & Glynn (1975)	Multiple baseline across behaviors (group design)	Y[b]	Y	N	Y	—	For objective measures only
Brigham, Graubard, & Stans (1972)	Multiple baseline across groups of subjects	Y	Y	N	Y	—	1. Found generalization across experimenters (teachers) 2. Found increase in time spent writing and improved attitude toward writing
Campbell & Willis (1978)	Multiple baseline across behaviors (group design)	Y	Y	N	N	A	
Fallon & Goetz (1975)	Multiple baseline across subjects	Y	N	Y	N	A	
Funderbunk (1976)	Control group	Y	Y	N	N	B	
Glover (1980)	Control group	Y	Y	N	N	A, B	
Glover & Gary (1976)	Multiple baseline across behaviors (group design)	Y	Y	N	N	—	
Glover & Sautter (1977)	Multiple baseline across behaviors (group design)	Y	Y	N	N	—	
Goetz (1981)	Multiple baseline across subjects	Y	N	N	N	—	
Goetz & Baer (1972)	Individual analysis with reversal	Y	?	Y	N	A	Maintenance examined for 1 subject only
Goetz & Salmonson (1972)	Individual analysis with reversal	Y	N	Y	N	—	
Holman, Goetz, & Baer (1977)	Multiple baseline across subjects and reversal	Y	N	Y	N	A, B	Maintenance examined in experiment 2 only
Lane, Lane, Friedman, Goetz, & Pinkston (1982)	Multiple baseline across subjects with control group	N[b]	Y	Y	N	B, C	Average agreement = .76
Maloney & Hopkins (1973)	Multiple baseline across behaviors (group design)	Y[b]	Y	N	Y	—	For objective measures only
Maloney, Jacobson, & Hopkins (1973)	Group design, multiple treatments sequentially applied	Y	Y	Y	Y	—	
Maltzman, Bogartz, & Breger (1958)	Control group	N	N	N	N	B	
Parsonson & Baer (1978)	Multiple baseline across behaviors and subjects	Y	N	Y	N	A, B	
Pryor, Haag, & O'-Reilly (1969)	Individual analysis	Y[b]	N	Y	N	—	Used coefficient of concordance
Ryan & Winston (1978)	Multiple baseline across behaviors	Y	N	N	Y	—	

[a] Key for "Method": Y = yes, N = no. Category: 1—adequate interobserver agreement; 2—blind scoring of products; 3—independent record of interaction; 4—social validation ratings; 5—types of generalization examined, A = temporal, B = task, C = setting.
[b] See comments in right-most column.

server to record both occurrences of the experimenter's behaviors and occurrences of the target behaviors, thereby raising the possibility that the observers themselves were influenced by the experimenter's behavior. Hearing the experimenter's reinforcing comments may have influenced their judgments of the target behaviors, and affected the independence of the recording. Future research should control for this problem.

Interobserver agreement. A study was defined as having adequate interobserver agreement if: (a) the reported agreement scores equalled or exceeded 80% agreement between two independent observers or (b) the correlation coefficient for two observers equalled or exceeded .80. The majority of studies met this criterion, but some did not have adequate agreement scores on all measures (Glover & Gary, 1976; Glover & Sautter, 1977). Only one study did not involve any such checks (Maltzman, Bogartz, & Breger, 1958).

Two methods of calculating interobserver agreement were employed. Five studies used a correlational method, whereas nine studies utilized a percentage agreement. In four studies, the method of computing agreement could not be determined from the report. Pryor, Haag, and O'Reilly (1969) reported a coefficient of concordance, making comparison with other measures difficult.

Social validation. Only six of the twenty studies used a social validation procedure in which independent judges provided subjective ratings of the creativity of work produced both before and after training. Four of these studies examined creative writing and two studies looked at children's drawings. The results indicated that not all behavioral targets were equally related to judgments of creativity. For example, Ryan and Winston (1978) reported that drawings reflecting increased form diversity received higher creativity ratings relative to baseline drawings, but those reflecting increased color diversity did not. Studies examining children's writing have found that higher creativity ratings have generally

been given to compositions produced under conditions that reinforced the use of different action words. These findings illustrate the usefulness of a social validation procedure for identifying which characteristics of creative products are socially relevant.

Generalization. The generalization and durability of changes in creative behavior are of obvious practical importance. Only ten of the studies examined these issues. Seven studies involved measures of cross-task generalization. In general, very limited generalization across tasks was seen. Holman et al. (1977) found cross-task generalization to be dependent on the degree of topographical similarity between tasks. Thus, generalization from pen drawing to painting was observed, but generalization from painting to block-building or to "Lego" block construction was not obtained. The failure to find spontaneous generalization of creativity training indicates the need to program generalization into the training procedures. Future research should explore this area (see Goetz, 1982, for an extended discussion). Cross-setting generalization is another area worthy of examination. Only one study investigated this issue (Lane et al., 1982).

Seven studies examined maintenance of the effects of creativity training at various stages. Parsonson and Baer (1978) observed maintenance of creative improvisations immediately after training. Baker and Winston (in press) and Fallon and Goetz (1975) reported maintenance of training effects 6 and 10 weeks after completion of the experiments. Holman et al. (1980) found maintenance of increased form diversity two months after training, but only for those subjects who had received many training trials. Glover (1980) found that increased scores on the Torrance Tests of Creative Thinking were maintained 11 months after the completion of the creativity training workshop.

Summary. In terms of basic methodological requirements, behavior analytic studies of creativity have generally been adequate. All of the studies have suitable replication procedures, nearly all have

minimally adequate interobserver agreement, and most have blind scoring of creative acts or products. Most of the studies, however, have been less than adequate in three areas: (1) an independent record of the experimenter-subject interaction during training is often lacking, (2) social validation of increased creativity was not provided in most studies, and (3) exploration of generalization issues has been limited. In addition, the simultaneous use of several different training procedures in some studies has made the effectiveness of individual components unclear. In some instances, the use of several procedures at once has created a confound between the instructions to the subject and the reinforcement contingencies. Finally, possible order effects complicate the interpretation of studies in which different procedures were employed successively.

DISCUSSION

Taken together, the results of the studies reviewed here leave little doubt that behavioral procedures can effectively alter a wide range of creative products with varied age groups. Although the methodology of the studies is generally adequate, the operational definitions and training procedures are problematic in a number of ways. In the following discussion, we will consider these difficulties and describe potential strategies for a more extensive analysis of creativity.

Definitions of Creativity

Most of the behavioral studies reviewed here used either increased diversity or novelty of products to define increased creativity. These two dimensions may serve as a fruitful starting point for the analysis, but diversity and novelty clearly do not encompass all of what is meant by creativity. Goetz (1984) has shown an admirable degree of caution in identifying the changes produced in her studies as "creativity." Diversity or novelty in a product may be defined in a variety of ways. Drawings, for example, vary in diversity of colors, geometric

forms, or real-life objects. In addition, the objects in the drawing may be novel for a particular child, all children, or all human history. The basis for identifying changes on any of these dimensions with increased creativity is unclear.

One solution to this problem lies in the use of "social validation," that is, subjective ratings by a group of suitable judges to validate the selection of target behaviors, procedures, or outcomes of behavioral intervention (Wolf, 1978). Behavioral creativity studies using this approach clearly indicate that some, but not all types of diversity are viewed by judges as more creative. In addition, the effect of increased diversity on creativity judgments might vary considerably across judges, cultures, and time.

A major difficulty with social validation is that such ratings generally do not constitute an experimental analysis of behavior. More than one dimension of a child's drawings may be changed by a training procedure, such as contingent reinforcement for diversity. If judges rate drawings produced after training as more creative than baseline drawings, this change in ratings may be due to a change in diversity, or a change in some other feature of the drawings that may be correlated with diversity (e.g., novelty). Nevertheless, social validation is a useful way of identifying potential discriminative stimuli that control the tacting of a product as "creative" in a specific culture and time (see Winston, 1984, for further discussion).

Even when increased diversity and novelty are found to have social validity as indicators of increased creativity, the issue of "informal stimulus control" raised by Sloane et al. (1980) remains a serious problem. Sloane et al. argued that informal stimulus control, rather than any particular topography, makes a response creative. In the studies reviewed here, we have no way to determine whether or not the products produced after training show increased informal control. Sloane et al. (1980) acknowledge that their notion of creativity is a difficult one for researchers, because the controlling discriminative stimuli cannot be determined from

the product alone. Moreover, the relationship between Sloane et al. distinction of formal versus informal control and Skinner's (1957) distinction of formal versus thematic control is not entirely clear. Skinner, for example, treated alliteration in poetry as a formal source of strength, whereas Sloane et al. referred to the repetition of sounds as informal control. A final problem is the uncertain relationship between informal stimulus control and other defining characteristics of a creative response.

Despite these difficulties, Sloane et al.'s (1980) cogent arguments for the role of informal control are a major challenge for future creativity research. Recently, Endo and Sloane (1982) taught children to generate novel sentences that contained personification of an inanimate object. Although this paper did not meet the criteria for inclusion in the present review, it clearly provides a model for creativity training though abstract stimulus control. Another potential strategy would be to train children to discriminate and verbally label the less obvious properties of an object that they were about to draw. Subsequently, reinforcement training could be used to make these tacts function as discriminative stimuli for drawing itself. For example, if a child were asked to draw a city, tacts such as "noisy," "dangerous," "exciting," "vibrating," or "dirty," could provide the basis for multiple, informal stimulus control and a more creative drawing.

A third issue in the definition of creactivity concerns the "quality" of creative products. Creativity training programs for young children are not concerned with the "quality" of the products; extinction or punishment of artistic behaviors in the early stages of skill development is obviously undesirable. But for adults and particularly for professionals, novelty alone is not sufficient. To be creative, a response must be appropriate, useful, or valuable in some way (Barron, 1969; Jackson & Messick, 1970; MacKinnon, 1962; Mednick, 1962). In Skinner's terms, "mutation must be followed by selection" (1970, p. 70). According to the philosopher Victor Thomas (1964):

Although we do not judge a work to be a work of creative art unless we believe it to be original, it is not enough that we should judge it to be merely different or novel. In discourse about art, we use "creative" in an honorific sense, in a sense in which creative activity always issues in something that is different in an interesting, important, fruitful, or other valuable way. If what the artist produces is a novelty, yet indifferent or bad, we do not regard him as a creator. (pp. 100–101)

From this perspective, a product must have both novelty and quality to be creative. Both traditional and behavioral researchers have generally ignored the issue of quality (see Glover & Sautter, 1977, for an exception). An analysis of the features that control tacting of a product as relevant, appropriate, or valuable would be extremely helpful. In certain domains, such as industrial design, we can identify objective features that make a novel product useful. For example, a novel automobile engine must have a certain level of durability. In the arts, where disagreements over aesthetic quality are wide ranging and acrimonious, and where judgments of quality are so often reversed over time, suggestions for an objective analysis of quality may seem ludicrous. Nevertheless, the behavior of judges and critics, even if unstable, is important for understanding the social context of creative activity (see Winner, 1982 for a discussion of agreement in aesthetic judgment).

Training Procedures for Creativity

The use contingent reinforcement to increase creative responding is problematic in several ways. First, well over 100 studies have reported an "overjustification" or "undermining" effect (see Deci & Ryan, 1981; Lepper & Greene, 1978). In the original overjustification studies, children who frequently chose to draw in a playroom situation were promised a "good player certificate" after drawing during a special session in the laboratory. Some weeks later, these children chose to draw less frequently than children who were not promised a certificate. This effect is taken to mean that "rewards" reduce intrinsic interest in an activity. Subsequent studies extended the effect to

other activities, rewards, and age groups. Early studies dealt only with single-trial procedures, while in some later studies, evidence for "undermining" was claimed for multiple-trial token reinforcement procedures (e.g., Greene, Sternberg, & Lepper, 1976). The interpretation of the effect remains controversial, but the effect itself is viewed by the general community of psychologists as well established. Unfortunately, many writers fail to note that: (a) the reward procedures used in the overjustification studies do not qualify as reinforcement procedures, (b) behavioral journals have published several failures to find such an effect (e.g., Feingold & Mahoney, 1975), (c) the methodological adequacy of some of the supporting studies has been questioned (e.g., Blocker & Edwards, 1982), (d) Lepper and Greene (1978) have themselves cautioned against a blanket indictment of token economies, and (e) the effect occurs only under certain conditions.

A full discussion of the adequacy and limitations of the "overjustification" literature is beyond the scope of this paper. The implications for the behavior analysis of creativity are obvious, however, when major review papers refer to extrinsic consequences for behavior as "the enemies of exploration" (Condry, 1977, p. 459). Moreover, a number of studies are frequently cited as evidence that "rewarded" or "extrinsically controlled" subjects produce products, such as drawings or problem solutions, that are rated as less creative than products produced by non-rewarded subjects (see Amabile, 1983, for a full description).

In a climate in which reinforcement for creativity may be viewed as damaging, behavioral researchers have several options. One approach would be to collect additional data regarding side effects. Although such data would not settle the "paradigm clash" (Kuhn, 1962) that appears to underlie the overjustification debate, the data would provide an interesting and valuable examination of possible side effects of true reinforcement procedures on creativity. Second, other behavioral procedures might be developed for enhancing creativity that do not rely primarily on contingent reinforcement, such as the use of self-instructions (Baker & Winston, in press). Third, behavioral creativity researchers must clearly point out that the special conditions under which overjustification effects occur are not often present in behavioral training studies (see Amabile, 1983). Whatever strategy is adopted, the possibility that behavioral training for creativity may indeed provide setting factors or discriminative cues that result in a variety of side-effects that should not be ignored.

Even if overjustification effects were not a major issue, the wider community may still object to the use of reinforcement training for creativity. The notions that creative activity must be "intrinsically motivated" and unconstrained by external evaluation are deeply held in our culture. If creativity is generally viewed as spontaneous "self-expression," then the notions of creativity and training through reinforcement may be seen as antithetical by educators and others involved in the supervision of children's creative activities.

Although behavior analysts may be inclined to dismiss such objections as one more example of a mystical and prescientific view of human behavior, the type of training used in many behavioral studies does pose a legitimate problem. As described earlier, Skinner (1953, 1971) argued that we do not label responses as "original" when the behavior is under obvious external control, such as following an instruction or a rigid formula. In Sloane et al.'s (1980) view, such behaviors are under formal stimulus control and are not creative. Some of the creativity training procedures reviewed here may also involve control that appears to be formal. For example, when a child is trained to increase diversity in drawings, very explicit instructions may be given, along with specific examples of new forms (e.g., Lane et al., 1982). The child's behavior may then be seen as under formal control of instructions to "draw a large number of different things" or "draw things you have not drawn before." In contrast, Parsonson and Baer's (1978) study of improvisation can be viewed as alteration of the stimulus control exerted

by a wide range of objects, rather than control by a specific set of instructions and contingencies (Sloane et al., 1980). Similarly, the use of self-instruction (Baker & Winston, in press) provides a way of teaching children to generate new discriminative stimuli for their drawings. Finally, Endo and Sloane's (1982) study of generative language training, as mentioned earlier, indicates the possibilities for a richer analysis of creativity based on stimulus control.

Analyzing the Creative Process

The studies reviewed here are largely "applied" in nature. As such, they are generally concerned with training rather than a detailed analysis of what normally goes on when we engage in creative activity. If we accept the notion that creativity involves complex chains of behavior, analysis of these chains may be of tremendous value for our understanding of creativity and our efforts to increase creativity.

In the traditional literature, the creative process is often described as having four phases: preparation, incubation, illumination, and verification (Stein, 1967; Wallas, 1926). Surprisingly, the sequences of behavior involved in the process of creating are rarely, if ever, subjected to direct analysis by behavior analytic or traditional researchers. Instead, the typical strategy is to reconstruct the behavior of the artist or writer post hoc through autobiographical or archival materials. An exception is the work of Della-Piana (1978), who developed a conceptual analysis of the revision process in writing and suggested how poets engaging in revision could be studied directly. In addition, Getzels and Csikszentmihalyi (1976) observed the behavior of art students in manipulating objects they were about to draw and took still photographs of the progress of the drawings. But in general, the tremendous power of behavioral observation methodology has not yet been used for studies of the creative process.

A related suggestion regarding the study of the creative process has been made recently by Glover and Dixon (1984).

They argued that notions of the creative process arising from cognitive psychology can serve as fruitful source of ideas for an enriched behavior analysis of creativity. For example, work on problem-solving suggests the possible behaviors used by expert problem-solvers as opposed to novices (e.g., Chase & Simon, 1973; Larkin, McDermott, Simon, & Simon, 1980). By extension, such work may suggest new behavioral strategies for creativity training.

Two additional, related areas of research in behavior analysis are clearly relevant to an extended analysis of creativity, but have not been considered in this review: studies of mediated transfer and conditional discrimination (e.g., Sidman, 1974, 1985), and studies of generative responding in language training (e.g., Endo & Sloane, 1982; Lutzker & Sherman, 1974). These areas of research both deal with the development of new stimulus control relationships and the emergence of untrained responses, and this work may therefore provide a basic analysis of the process by which novel, creative responses emerge. In order to integrate these areas with behavioral research on creativity, a detailed conceptual analysis will be required. Such an analysis is beyond the scope of the present paper.

Further analysis of the creative process is also available in Skinner's work, although he did not label the processes as "creativity." In Chapters 15 and 16 of *Verbal Behavior,* Skinner (1957) described "self-editing" in detail. This discussion is a rich source of ideas on how artists or writers respond to their own work, judge it good or bad, and continue, revise, or destroy their products. When the discussion of self-editing is considered along with Skinner's discussion of stimulus control, an extended view of the creative process emerges. We hope that future behavioral research on creativity will make greater use of such analyses.

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